DEPARTMENT OF TRANSPORTATION SERVICES

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET, 3RD FLOOR
HONOLULU, HAWAII 96813
Phone: (808) 768-8305 • Fax: (808) 768-4730 • Internet: www.honolulu.gov

MUFI HANNEMANN
Mayor

WAYNE Y. YOSHIOKA
DIRECTOR

SHARON ANN THOM
DEPUTY DIRECTOR

RECEIVED
2009 APR 30 A 10:28
CITY COUNCIL
HONOLULU, HAWAII

RECEIVED
APR 30 11 13 AM '09
CITY CLERK
HONOLULU, HAWAII

April 30, 2009

The Honorable Nestor Garcia, Chair
and Members of the Budget Committee
Honolulu City Council
530 South King Street, Room 202
Honolulu, Hawaii 96813

Dear Chair Garcia and Councilmembers:

Subject: BUDGET COMMUNICATION NO. 6

Per your letter dated April 1, 2009, concerning questions that were generated at the capital improvement budget hearings; the following is the Department of Transportation Services (DTS) response.

Item 14. Department of Transportation Services

Question 14 a) Was there a drop off in visitor ridership after the last fare increase and if so, how much?

Answer: Visitor pass sales do not appear to have been impacted by the increase in price from $15 to $20 dollars effective 7/1/03.

Fiscal Year	Visitor Passes Sold	Pass Price
2002	32,412	$15
2003	30,857	$15
2004	25,348 (Bus Strike)	$20
2005	30,637	$20
2006	28,588	$20
2007	29,851	$20
2008	30,821	$20
2009	30,500 (projected)	$20

Question 14 b) Please provide a white paper summarizing the department's findings on the success and shortcomings of the bus rehabilitation program and a recommendation as to whether it can and should be done on a larger scale versus purchasing new vehicles.

Answer: A white paper on the purchase of transit buses compared to the rehab of older buses is attached. The findings of this white paper are summarized below.

Rehabbing of Transit Buses Compared to Purchasing New Buses

FTA establishes guidelines for the frequency with which revenue vehicles can be replaced using federal funds. These replacement cycles establish the *useful life* over which the vehicle must operate. In practice, buses in Honolulu are replaced at the end of their *effective life* which is longer than the useful life. A growing number of buses exceed the minimum replacement age as specified by FTA. Currently, 275 buses are eligible for replacement using FTA's criteria that a bus must be at least 12 years old or have accumulated vehicle mileage in excess of 500,000 miles.

According to the most recent NTD data, in FY 2007, Honolulu had the fourth oldest fleet when the average age of the fleet was 8.6 years. Currently, the average age of the fleet is almost 10 years old. At this age, it is likely that Honolulu now has the oldest transit bus fleet in America. The graph below depicts the average age of all transit fleets with more than 200 buses at the end of the NTD 2007 reporting year compared with TheBus as of the end of April 2009. Honolulu is likely 74 or 75 out of 75 major U.S. transit systems in terms of average age of the bus fleet.

Over the next twenty-one months, we expect to receive 40 new buses. Currently, we are in the process of receiving 10 diesel-hybrid articulated buses. Additionally, it is expected that we will shortly place orders for an additional 20 diesel-hybrid articulated buses using ARRA stimulus funding and ten 35' foot conventional diesel buses. All of these buses are replacement buses. Delivery of new buses normally takes about a year following the awarding of a contract. By December 31, 2010, the fleet will include an additional 30 high-capacity articulated buses but the average age will have increased to 10.2 years. The number of buses eligible for replacement under FTA criteria will have increased to 285 buses.

Rehabilitation of Buses

Buses can be rebuilt or rehabbed at around the ten-year life. A rehab generally is a cosmetic upgrade which may include new flooring, rubber, windows, seats, paint, LED interior and exterior lights and mechanical equipment such as engines, transmissions, etc. It may include extensive body repair of corroded side panels, etc. and extensive cleaning of all parts of the bus.

Currently, Oahu Transit is committed to rehabbing about 12 buses per year. Our strategy now is to rehab buses that were purchased in 1995 and are now 13 years old. However, this leaves 99 older buses that are between 15-17 years old that we plan to retire ASAP rather than rehab. About 40 of these buses will be replaced by current planned orders leaving 59 buses that we plan to replace rather than rehab.

Rehabs divert maintenance manpower from other tasks. The current rate of rehabbing is the maximum rate at which in-house resources can be used. An alternative might be to contract out additional rehabs to the private sector as was done in the early eighties. While the in-house cost of rehabs is in the $80k-100k range (parts and labor), we estimate outside rehabs would be in the $120+k range. Rehabs could extend the useful life of a bus by about 4 years beyond the 12 year criteria. However, a rehab will not extend the life of the frame or axles or electrical systems and ultimately frames will crack, axles will break, electrical harness will become brittle and break and the body will rust to the point where it is not feasible to repair. This generally becomes acute at the 15-17 year life of the bus. For these reasons, the cost-effectiveness of rehabs is marginal given the high cost and the limited additional extended life.

The emissions on rehabbed buses are about 25 times dirtier than current generation clean-diesels or diesel-hybrids. Many mainland properties have agreements with EPA to aggressively replace older, dirtier buses with newer buses with cleaner engines.

With the current backlog of buses beyond the FTA useful life criteria, rehabs will be a fact of life for several years, even if new buses are purchased. In order for the City to maintain a sustainable bus fleet, about 40 buses per year, on average, need to be purchased each year. Therefore, we do not recommend rehabbing buses as a substitute to purchase.

Please don't hesitate to contact me if you would like to discuss this further.

Very truly yours,

Wayne Y. Yoshioka
Director

Attachment

APPROVED:

Rix Maurer III, Director
Budget and Fiscal Services

APPROVED:

Kirk W. Caldwell
Managing Director

Rehab Transit Buses as an Alternative to Purchasing New Diesel Hybrid or Clean-Diesel Buses

Oahu Transit Services, Inc.
Department of Transportation Services

April 2009

This report compares the relative pros and cons of new clean-diesel buses compared to diesel-hybrid buses and the potential of rehabbing buses as an alternative to purchasing new buses. It is largely based on the experience of actual TheBus operations and supplemented by published industry data.

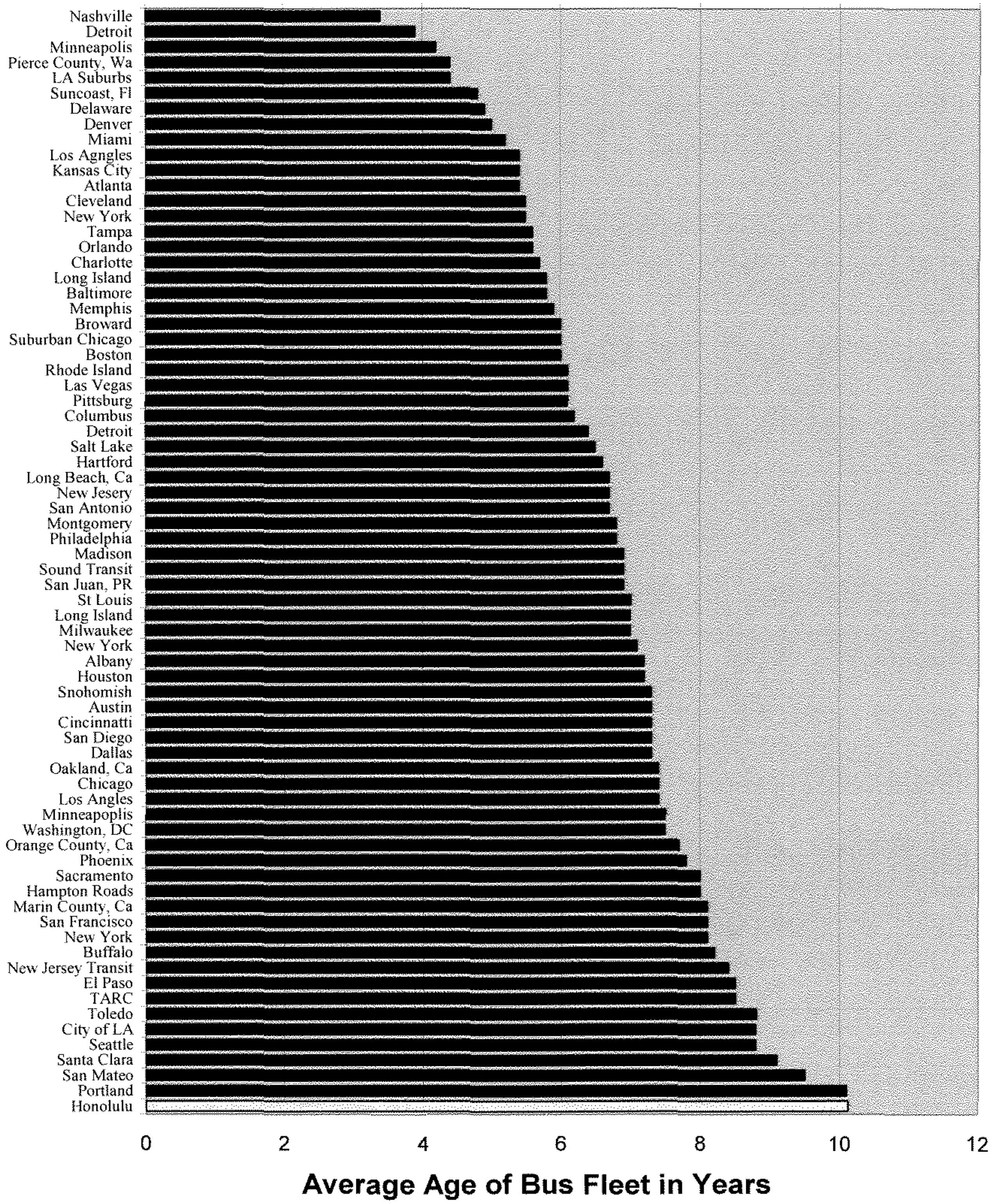
The City currently has a fleet of 531 transit buses as shown below. A growing number of buses exceed the minimum replacement age as specified by FTA. Currently, 275 buses are eligible for replacement using FTA's criteria that a bus must be at least 12 years old or have accumulated vehicle mileage in excess of 500,000 miles.

TABLE 1
Current City and County of Honolulu Bus Fleet As Of 3/31/09

Bus Numbers	Propulsion System	No of Buses in Fleet	Model Year	Manuf	Length	Age as of 3/31/09
202-283	Conventional	28	1993	TMC	40	15.8
51-62	Conventional	12	1993	TMC	35	15.4
601-659	Conventional	59	1994	Gillig	40	14.5
601-763	Conventional	73	1995	Gillig	40	14.5
774-795	Conventional	22	1996	Gillig	40	12.5
301-347	Conventional	47	1997	Gillig	40	11.5
348-365	Conventional	18	1998	Gillig	40	10.9
40-49	Conventional	10	1998	Gillig	30	10.9
366-368	Conventional	3	1998	Gillig	40	10.5
70-99	Conventional	30	2000	Flyer	60	8.9
801-835	Conventional	35	2000	Gillig	40	8.5
30-39	Conventional	10	2001	Chance	29	7.1
836-853	Conventional	18	2002	Gillig	40	7.0
25-29	Conventional	5	2002	Chance	29	6.4
100-115	Conventional	16	2002	Flyer	60	6.3
854-868	Conventional	15	2003	Gillig	40	5.3
501-555	Conventional	55	2003	Gillig	40	5.2
116-131	Conventional	16	2003	Flyer	60	5.0
132-141	Hybrid	10	2004	Flyer	60	4.4
901-940	Hybrid	40	2006	Flyer	40	2.6
142-150	Conventional	9	2007	Flyer	60	1.3
Total		**531**		**Average Age**		**9.78**

According to the most recent NTD data, in FY 2007, Honolulu had the fourth oldest fleet when the average age of the fleet was 8.6 years. Currently, the average age of the fleet is almost ten years old. At this age, it is likely that Honolulu now has the oldest transit bus fleet in America. The graph below depicts the average age of all transit fleets with more than 200 buses at the end of the NTD 2007 reporting year compared with TheBus as of the end of April 2009. Honolulu is likely 74 or 75 out of 75 major U.S. transit systems in terms of average age of the bus fleet.

Average Age of U.S. Transit Bus Fleets



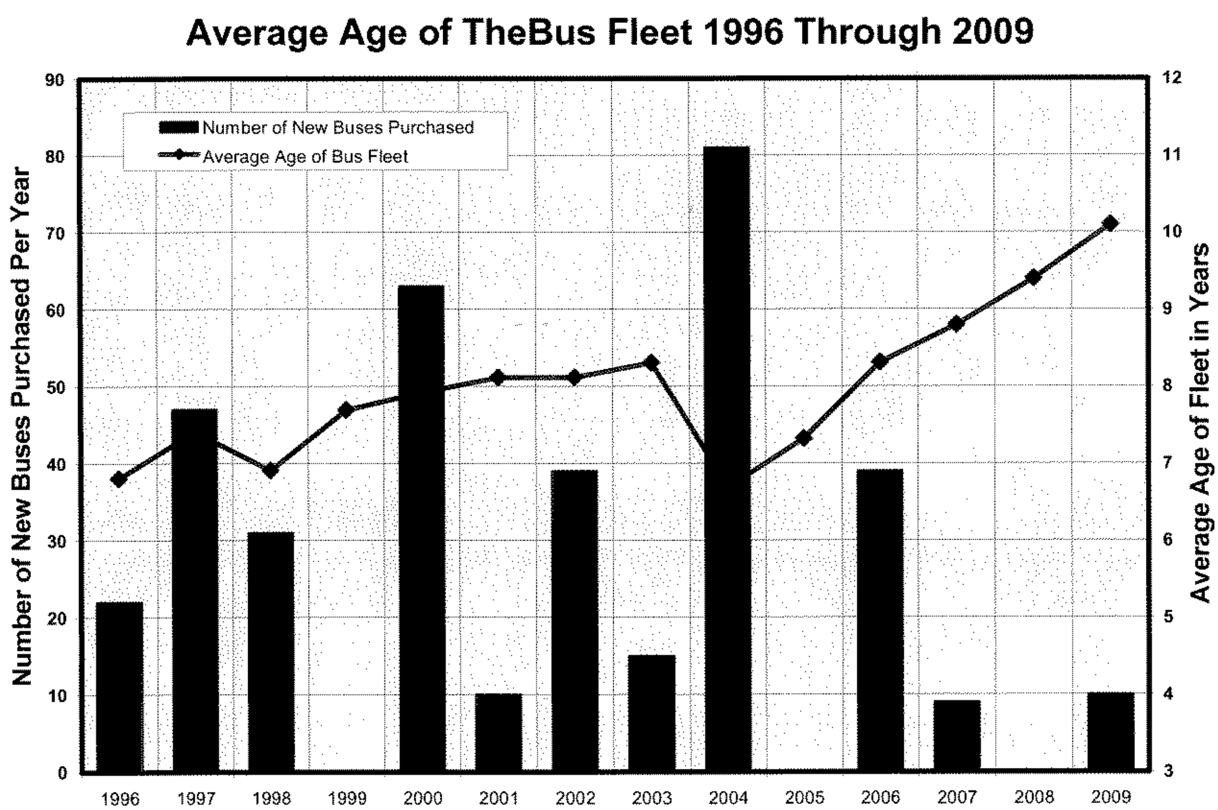
Source: 2007 National Transit Database except Honolulu adjusted to 6/30/2010 based on current orders of buses.

Over the next twenty-one months, we expect to receive 40 new buses. Currently, we are in the process of receiving ten diesel-hybrid articulated buses. Additionally, it is expected that we will shortly place orders for an additional 20 diesel-hybrid articulated buses using ARRA stimulus funding and ten 35' foot conventional diesel buses. All of these buses are replacement buses. Delivery of new buses normally takes about a year following the awarding of a contract.

By December 31, 2010, the fleet will include an additional 30 high-capacity articulated buses but the average age will have increased to 10.2 years. The number of buses eligible for replacement under FTA criteria will have increased to 285 buses.

Increased Cost of Buses

There are several reasons that have driven the increase in the average age of the fleet. For the past few years, Honolulu has concentrated on purchasing both higher capacity (and higher cost) articulated buses and also hybrid-propulsion systems. Hybrid articulated buses are almost $1 million each compared to about $380,000 for typical 40' diesel buses. Consequently fewer buses have been purchased in recent years, and the average age of the bus fleet has increased commensurately. In order for the City to maintain a sustainable bus fleet, about 40 buses per year, on average, need to be purchased each year.



Prices for heavy-duty transit buses range from about $350,000 to $1 million. Heavy-duty vehicles generally have a twelve-year to fifteen-year life. For very low density routes, cutaway vans could be used but the life of these vehicles is generally only four to five years. In Hawaii, manufacturers must add on the cost of the GET and shipping to Hawaii. This can increase the cost of a heavy duty transit bus from $25,000 to $60,000 per bus. The current "typical price for buses delivered to Honolulu is shown in the chart below.

TABLE 3 - Number of Buses That Can Be Purchased for a $20 million CIP Budget									
Type of Bus	**Exp. Life (yrs)**	**Est. Cost per Bus FOB Honolulu**	**No. of Buses for $20 Mil**	**No. of Seats**	**Standing Cap**	**Bus Total Cap**	**System Total Cap**	**Cost per Seat**	**Cost per Person**
60' Articulated Hybrid-Diesel	12-14	$975,000	20	57	46	103	2060	$17,105	$9,466
60' Articulated Clean-Diesel	12-14	$760,000	26	57	46	103	2678	$13,333	$7,379
45' Hybrid-Diesel Transit Bus	14-16	$760,000	26	46	30	76	1976	$16,522	$10,000
45' Clean Diesel Transit Bus	14-16	$560,000	35	46	30	76	2660	$12,174	$7,368
45' Clean Diesel Commuter Bus	15-18	$500,000	40	57	18	75	3000	$8,772	$6,667
40' Hybrid-Diesel Transit Bus	12-14	$590,000	33	38	24	62	2046	$15,526	$9,516
40' Clean Diesel Transit Bus	12-14	$395,000	50	38	24	62	3100	$10,395	$6,371
40' Clean Diesel Commuter Bus	15-18	$460,000	43	49	14	63	2709	$9,388	$7,302
35' Clean Diesel Transit Bus	12-14	$350,000	57	30	18	48	2736	$11,667	$7,292
30' Clean Diesel Transit Bus	12-14	$330,000	60	25	15	40	2400	$13,200	$8,250
28' Cutaway Van	4-5	$150,000	133	16	6	22	2926	$9,375	$6,818

Reduced Federal Grants Available for Bus Purchases

Generally Honolulu has budgeted between $25 million to $30 million per year in new bus purchases within the CIP budget, anticipating that 20 percent of the costs will be locally financed and 80 percent of the costs will be financed through a federal transit grant. However, in recent years, often there is not sufficient federal grant dollars available.

There are generally two sources of federal grants available for Honolulu. These are the §5307 formula grant program and the discretionary §5309 earmarked bus and bus facility program. The §5307 (together with the fixed guideway modernization program) yielded about $31 million for Honolulu in FY 2008. However, in recent years, about $21 million from this amount has been allocated to defray maintenance operating costs leaving only about $10 million for other projects including the purchase of buses, facilities, and transit centers.

About six years ago, Congress began distributing some of the §5307 program partially based on §5340—High Density States and Growing States—provision. This section of the formula program discriminates against Hawaii and 42 other states. In FY 2008, Hawaii lost more than $2 million in formula grants as a result of §5340.

A second FTA bus grant program, the discretionary §5309—Bus and Bus Related Program—has been substantially reduced over the last few years. For the past two years, only $1.3 million has been earmarked by Congress for Honolulu bus programs. This has reduced the amount of federal funding that historically has been allocated toward new bus purchases. In the same period, more funding has been earmarked for rural bus programs in the neighbor island counties. The table below indicates the amount of §5309 FTA funding apportioned to Honolulu in the past eight years.

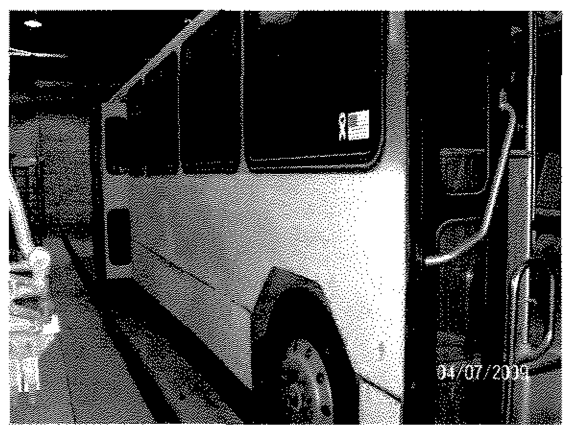
TABLE 2 FTA § 5309 - Bus and Bus Facility Allocations Over the Past Few Years								
Fiscal Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Amount	$5,941,889	$8,662,754	$8,607,188	$7,506,078	$7,466,215	$7,350,000	$1,300,000	$1,300,000

Rehabilitation of Buses as an alternative to Purchasing New Buses

Buses can be rebuilt or rehabbed at around the ten-year life. A rehab generally is a cosmetic upgrade which may include new flooring, rubber, windows, seats, paint, LED interior and exterior lights and mechanical equipment such as engines, transmissions, etc. It may include extensive body repair of corroded side panels, etc. and extensive cleaning of all parts of the bus.

Currently, Oahu Transit is committed to rehabbing about 12 buses per year. Our strategy now is to rehab buses that were purchased in 1995 and are now 13 years old. However, this leaves 99 buses that are between 15-17 years old that we plan to retire ASAP rather than rehab. About 40 of these buses will be replaced by current planned orders leaving 59 buses that we plan to replace rather than rehab.

Rehabs divert maintenance manpower from other tasks. The current rate of rehabbing is the maximum rate at which in-house resources can be used. An alternative might be to contract out additional rehabs to the private sector as was done in the early eighties. While the in-house cost of rehabs is in the $80k-100k range (parts and labor), we estimate outside rehabs would be in the $120+k range. Rehabs could extend the useful life of a bus by about 4 years beyond the 12 year criteria. However, a rehab will not extend the life of the frame or axles or electrical systems and ultimately frames will crack, axles will break, electrical harness will become brittle and break and the body will rust to the point where it is not feasible to repair. This generally becomes acute at the 15-17 year life of the bus. For these reasons, the cost-effectiveness of rehabs is marginal given the high cost and the limited additional extended life.



The emissions on rehabbed buses are about 25 times dirtier than current generation clean-diesels or diesel-hybrids. Many mainland properties have agreements with EPA to aggressively replace older, dirtier buses with newer buses with cleaner engines.

With the current backlog of buses beyond the FTA useful life criteria, rehabs will be a fact of life for several years, even if new buses are purchased. In order for the City to maintain a sustainable bus fleet, about 40 buses per year, on average, need to be purchased each year. Therefore, we do not recommend rehabbing buses as a substitute to purchase.

Diesel-Hybrid Buses Compared to Conventional Diesel Buses

There are four hybrid bus systems in the U.S. transit market. These are described below.

Allison Parallel Drive System

The Allison system is a so-called *parallel* hybrid system whereby both electric motor traction and direct diesel engine traction are blended to provide propulsion to the wheels. At starting acceleration, electric motors within the Allison transmission provide the propulsion. Electric motors produce high torque, which is ideal for startup. As the engine ramps up to an optimum RPM, more of the direct energy from the engine is blended through the transmission to the wheels. Decoupling the diesel engine from the wheels at start-up reduces emissions and unburnt fuel.

The Allison hybrid also improves MPG by using regenerative braking. As the bus stops, the electric transmission motors runs backwards causing the bus to slow and also charging the batteries. The system is controlled by a proprietary control system that continually monitors vehicle and engine operation and controls both the engine and transmission for optimum performance. A dual power inverter module changes stored DC battery power to AC to power the electric motors within the transmission and also converts AC power from the regenerative braking system to DC power for storage. The regenerative braking system also drastically increases conventional disk brake life since the hybrid-propulsion system provides most of the braking. In Honolulu, OTS reports brake life is expected to double on hybrid-buses. Other propulsion-related maintenance costs may also be less such as engine and transmission wear because the hybrid system isolates the engine from the wheels resulting in less stress.

Series Hybrid System

Several manufacturers produce a *series* hybrid system whereby an auxiliary power unit provides electric power to charge batteries and power electric traction motors. A large part of the propulsion power is provided through a large number of batteries. A series hybrid is all-electric compared to the parallel system whereby propulsion power is blended between the diesel engine and electric motors within the transmission. Most of the system accessories are electric-powered rather than mechanically-powered from the engine. These include the air conditioning system, power steering, and braking system. The auxiliary power unit can be powered by a number of different power sources. ISE Corporation has used both gasoline and diesel engines while BAE system markets a diesel engine-powered unit. Both companies are experimenting with other power sources including compressed natural gas (CNG) and hydrogen fuel cells.

One of the purported advantages of the series type hybrid engines are that somewhat smaller engines is required compared to the parallel system. For example, the BAE system uses a 5.9 liter ISB Cummings engine rated at 250 HP. This is about the same size as a medium-sized pick-up truck. The Allison system that is used in Honolulu uses an 8.9 liter Cummings ISL diesel engine rated at 330 HP. The series hybrid has a relative advantage over the parallel hybrid in the densest CBD-type service areas.

New York City has an on-going evaluation with Designline buses—a new entrant in the hybrid bus market. The Designline product uses a micro turbine APU that provides power required to charge the batteries. The gas turbine is by nature a "flex fuel" engine and a variety of fuels including diesel, kerosene, aviation fuel, or bio-diesel can be used. This system relies upon stored battery power to a greater extent than the other two series hybrid manufacturers. In fact, the Designline bus is more of a battery bus with a small generator. New York City has agreed to purchase up to 100 vehicles in various phases conditioned on successful operation of the initial units. Preliminary reports from by New York City Transit suggest the fuel economy of the Designline vehicle is superior to the other hybrid system.

Purchase Price Differential for Hybrid Buses

The purchase price differential between a conventional diesel propulsion system and a diesel-hybrid propulsion system ranges from about $190,000 to $215,000 more for the hybrid. The price differential has gone down only slightly since hybrid buses were first introduced about six years ago. Hybrid buses have a bank of high-technology NiCad batteries stored on the roof of the vehicle. The battery pack is expected to last five to eight years, which means that the pack will need to be replaced at least once during the life of the vehicle and possibly twice. The battery pack adds significant weight to the vehicle. Battery packs are currently about $40,000.

Fuel Economy of Hybrid Buses

Relative fuel savings for hybrid buses are greatest when the duty cycle includes typical Manhattan-style congestion levels (about 6 mph) with more than 10 stops per mile. In this environment, New York City Transit reports fuel savings of about 28 percent compared to non-hybrid diesels. On the other end of the scale, a commuter run with most of the operation on a freeway will show little or no savings. In fact, MCI reports that hybrid commuter buses use slightly *more* fuel on some long (35 mile or longer) commuter runs in the NY region. The table below indicates the hybrid fuel economy results in a number of larger cities.

TABLE 4 - Comparison of Hybrid Bus MPG Improvements From Different Cities

City	Agency	Bus Manuf	System	Type	Results
New York [1]	NYCTA	Orion	BAE	Series	Up to 30% for NY CBD
Seattle [2]	METRO	New Flyer	Allison	Parallel	10-20%
Toronto [3]	TTC	Orion	BAE	Series	10%
FTA [4]	National	Mix	Different	Mix	18.6% average for all routes

Local Analysis of Hybrid-Bus Fuel Economy

Honolulu has operated hybrid buses since 2004 and has about five years' experience. Oahu Transit has measured the MPG of different fleets for years but comparison of conventional diesel propulsion to Diesel-hybrid propulsion is still difficult for a variety of reasons.

- Different engines can affect fuel economy. For example, OTS has a program to repower poor performing Detroit Diesel S-50 engines with Cummings engines on some older articulated buses. The newer engines have 17 percent better fuel economy than the older engines.

[1] BAE/Orion Hybrid Electric Buses at New York City Transit A Generational Comparison, National Renewable Energy Laboratory; March 2008 http://www1.eere.energy.gov/vehiclesandfuels/avta/pdfs/heavy/bae-orion_he_buses.pdf)
[2] King County Metro Transit Hybrid Articulated Buses: Final Evaluation Results, Technical Report, National Renewable Energy Laboratory,NREL/TP-540-40585; December 2006
[3] TTC going diesel again after hybrid bus glitch; Toronto Star; Oct 18, 2008: http://www.thestar.com/News/GTA/article/519770
[4] Analysis of Electric Drive Technologies for Transit Applications: Battery-Electric, Hybrid-Electric, and Fuel Cells, Federal Transit Administration, U.S. Department of Transportation; August 2005. http://www.fta.dot.gov/documents/Electric_Drive_Bus_Analysis.pdf

- The service profile of each route is different. For example, diesel-articulated buses in the Pearl City Division have 7 percent better fuel economy than the diesel-hybrid buses in the Kalihi Division. The Kalihi buses use caterpillar engines and are usually placed on the Limited Stop Route A service from Waipahu to UH while the diesel-articulated buses at Pearl City generally operate on the freeway for extended periods of travel.

- Some buses are larger and heavier than other buses. As the weight of a bus increases, the MPG decreases.

- Bus transmissions and axles can be geared differently affecting fuel economy.

- Of increasing importance, electronic controls for engines are becoming more sophisticated. Some newer engines can automatically shift the bus into neutral while at idle which reduces the load on the engine and can improve MPG.

TABLE 5
Miles Per Gallon (MPG) Comparisons of Different Fleets of OTS Buses

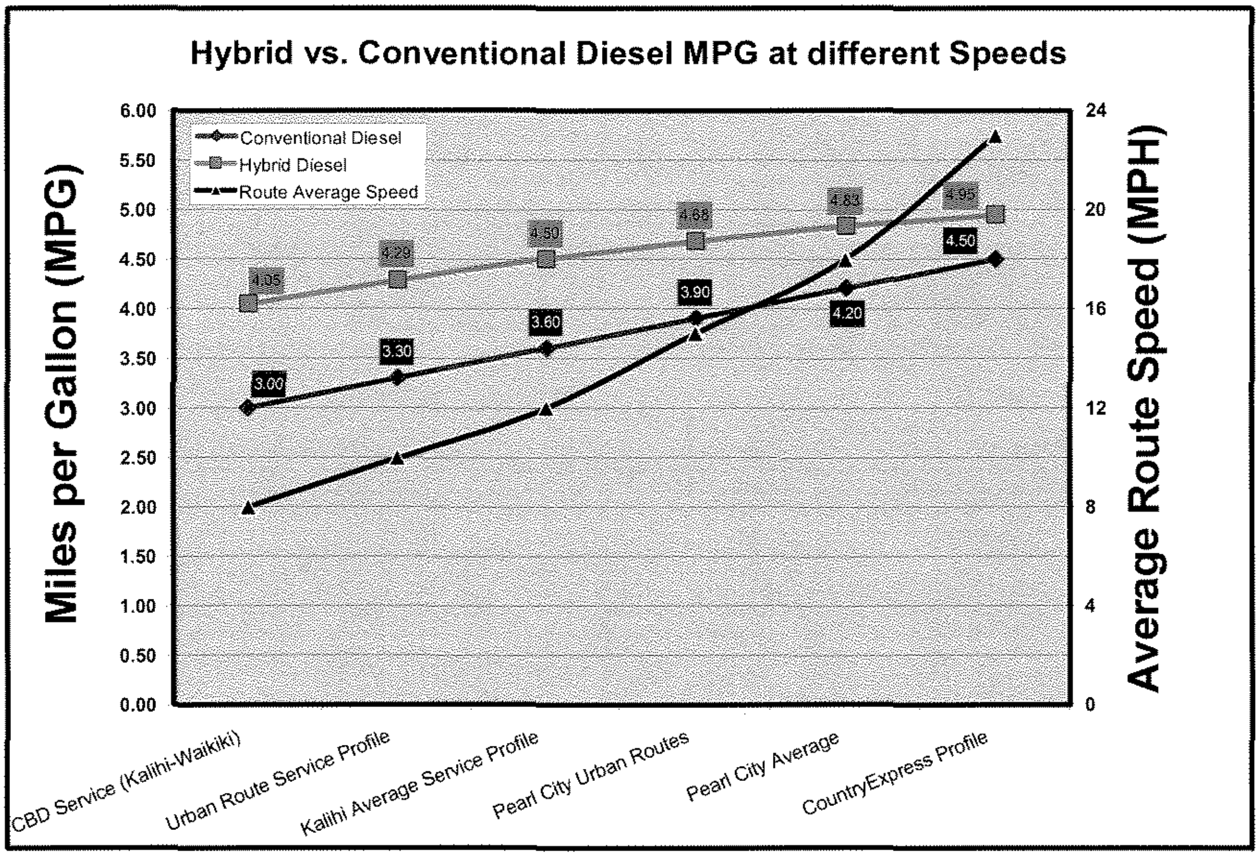
	---------------------------- Bus Length			--------------------------------
Averages	30'	35'	40'	60'
Kalihi-S50 Engine				1.96
Kalihi Conventional	4.23	3.32	3.57	2.30
Cummings Improvement				17.8%
Kalihi Hybrid	None	None	4.27	3.01
Kalihi Hybrid Improve	NA	NA	19.6%	30.5%
Hybrid Service Profile Differences	NA	NA	Same Service Profile Both Urban Trunk	Urban Trunk Conventional vs. Limited Stop
Pearl City Conventional	4.56	None	4.30	3.22
Pearl City Hybrid	None	None	None	None
Improvement				
Pearl City over Kalihi	7.6%		20.5%	7.1%
Division Service Profile Differences	Hill Climber vs. Suburban Circulator Service	NA	Predominate Urban Trunk Kalihi vs. Suburban Trunk Pearl City	Urban CBD Trunk Suburban Limited Stop Freeway Service

Cost-Effectiveness Analysis: 40' Diesel Buses vs. 40' Diesel-Hybrid Buses

We undertook a cost effectiveness analysis to determine if the benefits from the hybrid buses (primarily fuel but also some maintenance cost savings) outweighed the substantially higher purchase costs for diesel-hybrid buses.

As can be seen by the graph below, all buses have higher MPG as the average speed of a route increases (blue line). But the greatest *relative* advantage from hybrids occurs in the heavily-congested CBD duty cycle when average route speeds are 8 MPH or less. On the other hand, while the relative advantage of hybrids goes down as average speed increases, the annual and cumulative miles increases to the extent that the bus is used on suburban or limited-stop service. Some buses at the Pearl City Division accrue more than 60,000 miles per year.

Relative Performance of Hybrid Bus Compared to Conventional Diesel at Different Service Profiles



Since hybrid buses perform differently for different duty cycles, we analyzed the cost effectiveness for six different duty-cycle scenarios as present below.

Table 6 – Assumptions about Hybrid Efficiency in Different Transit Duty Cycles

Bus Duty Cycle Service Profile	Average Speed	Miles per Year	Lifetime Bus Miles	Hybrid % Improve	Diesel MPG	Hybrid MPG
Typical CBD Service	8	24,000	305,633	35.00%	3	4.05
Typical Trunk Arterial Service	10	29,000	369,216	30.00%	3.3	4.29
Typical Urban Feeder Service	12	36,000	458,337	25.00%	3.6	4.5
Typical Suburban Trunk Service	15	42,000	534,727	20.00%	3.9	4.68
Typical Suburban Route Service	18	53,000	674,774	15.00%	4.2	4.83
Typical Country-Express Service	23	64,000	814,822	10.00%	4.5	4.95

Fuel Cost Increase Scenarios

For the purpose of cost-effectiveness analysis, we analyzed three different fuel cost increase scenarios. Fuel is currently about $2.00 per gallon (March 2009) but did increase to $4.61 in August of 2008. All of these scenarios assume that fuel will be $2.78 per gallon next year as currently forecast by the Energy Information Administration of the U.S. Department of Energy. .

For purposes of sensitivity, we analyzed the following three scenarios:

Scenario 1 – Department of Energy Forecast: We used the current energy price forecast for transportation (diesel fuel) published by the Energy Information Administration, U.S. Department of Energy.[5] This forecast assumes that diesel will be $2.78 per gallon in 2010 and will increase to $4.92 in nominal dollars by 2024. This represents an annual average increase in cost of 4.58 percent per year.

Scenario 2 – High Fuel Increases each year: We assumed that diesel fuel will be $2.78 per gallon in 2010 and thereafter increased 12 percent per year until it reached $12.13 per gallon in 2024 years.

Scenario 3 – Hyper Fuel Increases each year: We assumed that diesel fuel will be $2.78 per gallon in 2010 and thereafter increased 20 percent per year until it reached $29.74 per gallon in 2024 years.

Maintenance Cost Assumptions

Hybrid buses have some advantages and disadvantages when it comes to maintenance costs. We assumed the following based on the average service profile for the Pearl City Division.

Brake Life: We assumed brake life for a non-hybrid bus at about 80,000 miles and expect that brake life will almost double for hybrid bus to 150,000 miles between brake relines. More of the braking for a hybrid is done through the regenerative system compared to a non-hybrid bus with a hydraulic retarder. Advantage: Hybrid buses.

Engine Life: We assumed that engine life for a hybrid bus would be significantly longer than for a non-hybrid bus since the stress from acceleration is decoupled from the diesel engine. Current generation engines get about 360,000 miles before overhaul. We anticipate hybrids will go 450,000 miles between overhauls. Advantage: Hybrid buses.

Transmission Life: We assumed transmission life would be extended from 250,000 miles between overhauls to 400,000 miles between overhauls. However, unlike a conventional transmission, we will need to have the transmission overhauled or replaced by the manufacturer. Advantage: Unclear until cost of transmission repair determined.

Batteries: A conventional bus replaces one of the lead acid batteries about every 12,000 miles resulting in a battery cost of about $0.008 per mile. However, we assume the battery pack on the hybrid will need to be replaced once in the life of the bus resulting in a very high $0.222 per mile. Advantage: Conventional buses.

---

[5] Energy Information Administration, U.S. Department of Energy, Annual Energy Outlook 2009 Early Release, Report #:DOE/EIA-0383(2009), Release Date: December 2008

Fuel Savings

As expected, maximum fuel savings occurred in the CBD duty cycle where a hybrid has its maximum relative performance. These are buses on routes where the average speed is 8 mph or less and the annual mileage accrued is about 24,000 miles. A conventional diesel gets about 3 mpg and requires about 8,000 gallons of fuel. A hybrid is about 35 percent more efficient and uses only 5,926 gallons—a savings of about 2,000 gallons per year. Over the course of a fourteen-year life, a bus operating on the CBD duty-cycle profile might accrue about 300,000 miles. A conventional diesel would use about 100,000 gallons of fuel while a hybrid would use about 75,000 gallons—a difference of about 25,000 gallons.

At the other end of the scale, a bus that operated in a CountryExpress duty cycle are on routes where the average speed is 23 mph or more and where the average annual mileage is about 64,000 miles per year. A conventional diesel bus would get about 4.5 mpg and would use about 14,200 gallons of fuel. A hybrid would be about 10 percent more efficient and would get about 4.95 mpg and would use about 12,900 gallons of fuel—a savings of about 1,300 gallons per year. Over a typical bus life, a vehicle operating on this duty cycle might travel about 815,000 miles. A conventional diesel would use about 181,000 gallons of fuel while a hybrid would use about 164,600—a difference of about 16,500. Interestingly, a bus traveling on higher speed routes receives less relative advantage than a bus on a stop and go route but the higher vehicle mileage somewhat compensates for the lack of relative performance.

Comparison of Calculated Life-Cycle Costs

A simulation was performed of the costs of the six duty cycles and the three fuel increase scenarios. In all, 6 duty cycles times 3 fuel cost assumptions = 18 cases were analyzed. A comparison was done using both current dollars (not adjusted for inflation) and constant dollars (i.e., adjusted for inflation). In all simulations, the constant dollar cost (i.e., adjusted for inflation) was lower for the conventional diesel compared to the hybrid vehicle. Using current dollars (i.e., not adjusted for inflation), the hybrid bus was less costly only when the rate of fuel increase reached 20 percent per year. This is much higher than government forecasts. The latest forecast from the Energy Information Administration, U.S. Department of Energy predicts an annual 4.58 percent inflation rate in the price of diesel distillates for transportation. According to the latest DOE report, diesel prices would increase from about $2.76 per gallon in 2009 to $4.94 per gallon in 2024. [6] The results of this simulation are presented in the table below. The only case in which the hybrid bus is less costly over the projected life of the vehicle was in the case of hyper-fuel inflation in which the price of diesel would rise from about $2.00 per gallon today to almost $30 per gallon by 2024. This scenario is 430 percent higher than predicted by current federal government statistics.

[6] Energy Information Administration, U.S. Department of Energy, Annual Energy Outlook 2009 Early Release, Report #:DOE/EIA-0383(2009), Release Date: December 2008

TABLE 7

Summary of Lifetime Fuel Savings	Lifetime Consumption of Diesel Fuel				
	Lifetime Bus Mileage	Conv Diesel	Diesel Hybrid	Lifetime Hybrid Savings	Percent Savings
CBD Service (Kalihi-Waikiki)	305,633	101,853	75,447	26,406	25.9%
Urban Route Service Profile	369,216	111,885	86,066	25,819	23.1%
Kalihi Division Average	458,337	127,316	101,853	25,463	20.0%
Pearl City Urban Routes	534,727	137,108	114,255	22,853	16.7%
Pearl City Average	674,774	160,659	139,704	20,955	13.0%
CountryExpress Profile	814,822	181,071	164,608	16,463	9.1%

TABLE 8

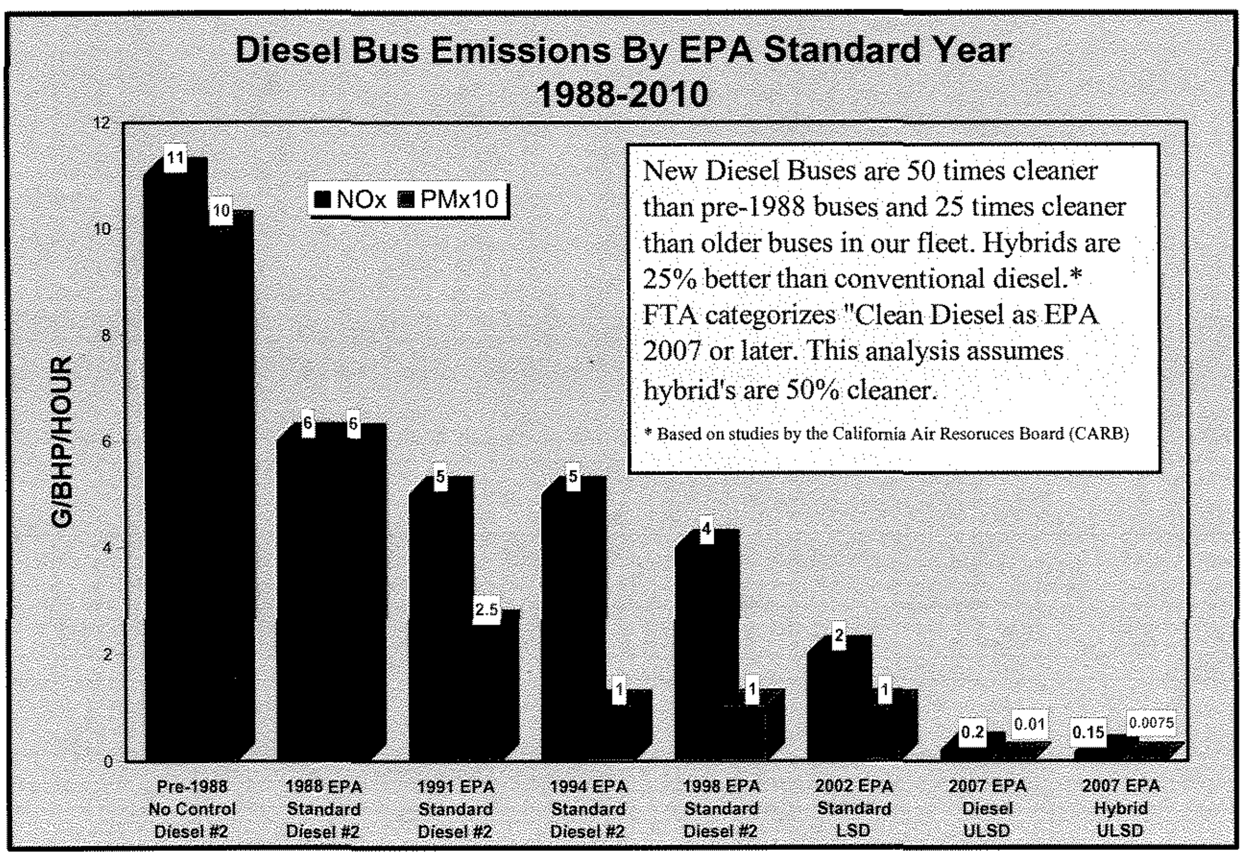
Summary of Financial Savings	-------DOE-EIA Estimate (4.58%)--------			-------High Fuel Inflation (12%)----------			-----Hyper Fuel Inflation (20%)-----		
	Life time Costs			Life time Costs			Life time Costs		
	Conv Diesel	Diesel Hybrid	Hybrid Premium	Conv Diesel	Diesel Hybrid	Hybrid Premium	Conv Diesel	Diesel Hybrid	Hybrid Premium
CBD Service (Kalihi-Waikiki)	$804,022	$921,648	$117,626	$1,014,112	$1,077,268	$63,155	$1,555,050	$1,473,841	-$81,209
Urban Route Service Profile	$850,947	$963,733	$112,787	$1,081,728	$1,141,260	$59,531	$1,675,943	$1,597,336	-$78,607
Kalihi Division Average	$921,385	$1,026,464	$105,079	$1,183,994	$1,236,554	$52,559	$1,860,156	$1,777,001	-$83,156
Pearl City Urban Routes	$970,007	$1,124,215	$154,208	$1,252,818	$1,359,888	$107,069	$1,980,997	$1,942,657	-$38,340
Pearl City Average	$1,078,306	$1,175,493	$97,187	$1,409,689	$1,463,657	$53,968	$2,262,927	$2,215,390	-$47,537
CountryExpress Profile	$1,175,867	$1,284,339	$108,472	$1,549,360	$1,623,871	$74,511	$2,511,025	$2,498,093	-$12,933

Environmental Benefits of Hybrid Buses

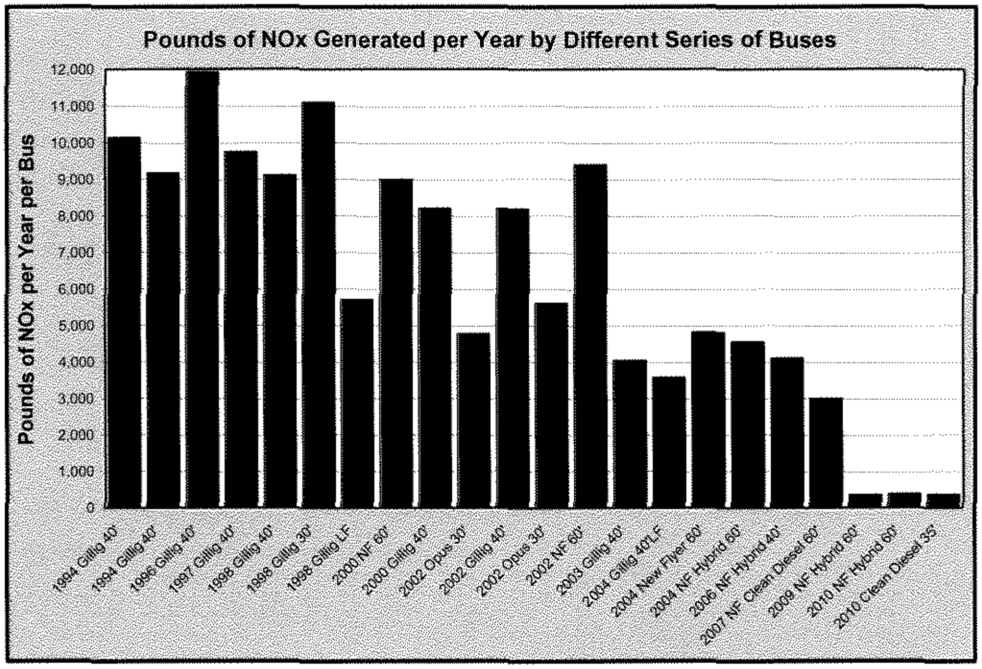
Hybrid buses emit fewer pollutants such as particulate matter (PM), various nitrous oxides (NO_x) and greenhouse gases compared to conventional diesel buses. There is still debate over how much reduction a hybrid bus does provide when compared to today's "clean diesels." FTA considers a vehicle to be a "clean diesel" if it meets the EPA 2007 emission standards for heavy duty diesel engines. In the absence of definitive tests, the California Air Resources Board (CARB) credits hybrid buses with being 25 percent cleaner than conventional diesels. The reasoning by CARB is that hybrids should be credited with at least the smaller amount of fuel burned. The EPA does not recognize this credit at this time and relies only on the rating of the diesel engine.

Hybrids may reduce particulate matter (PM) even more than fuel saved since the electric motor generally propels a bus from a stop and more particulate matter is emitted during acceleration from a conventional diesel than by cruising once acceleration is completed.

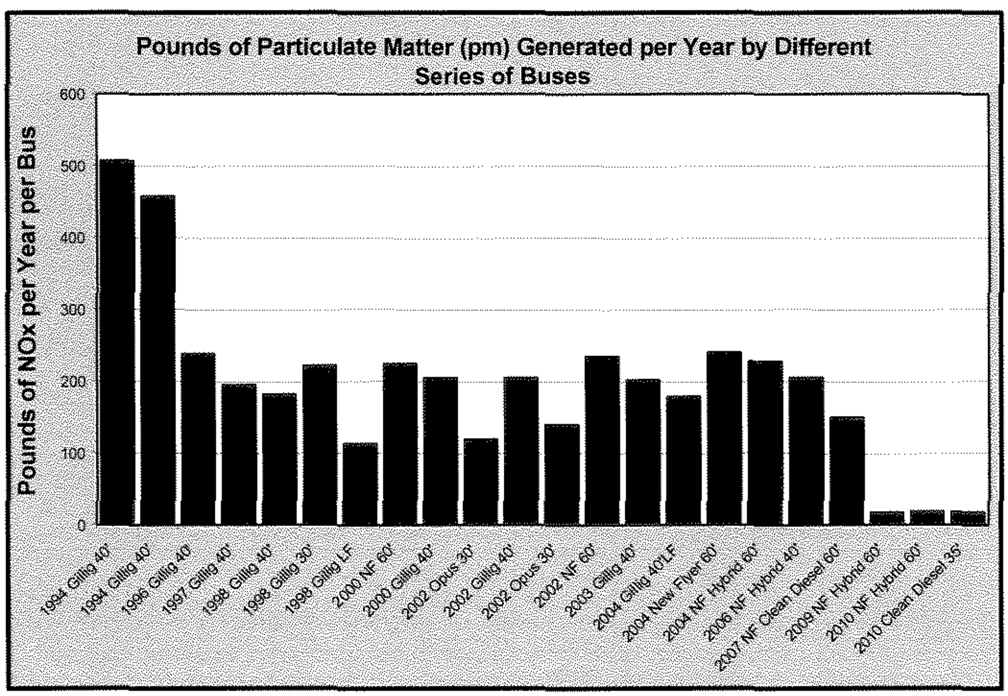
While there is a debate over exactly how clean a hybrid bus is compared to a conventional diesel with the latest engines, there is no debate that older engines are substantially dirtier than current clean diesel engines used by both hybrids and conventional propulsion diesel buses. EPA issued its first heavy-duty diesel engine standards in 1988. Since then, EPA has issued seven increasing stringent standards for maximum emissions. Today's clean diesel engines are 50 times cleaner than the pre-1988 regulation environment and 25 times cleaner than our oldest buses. A graphical representation of EPA standards is below.



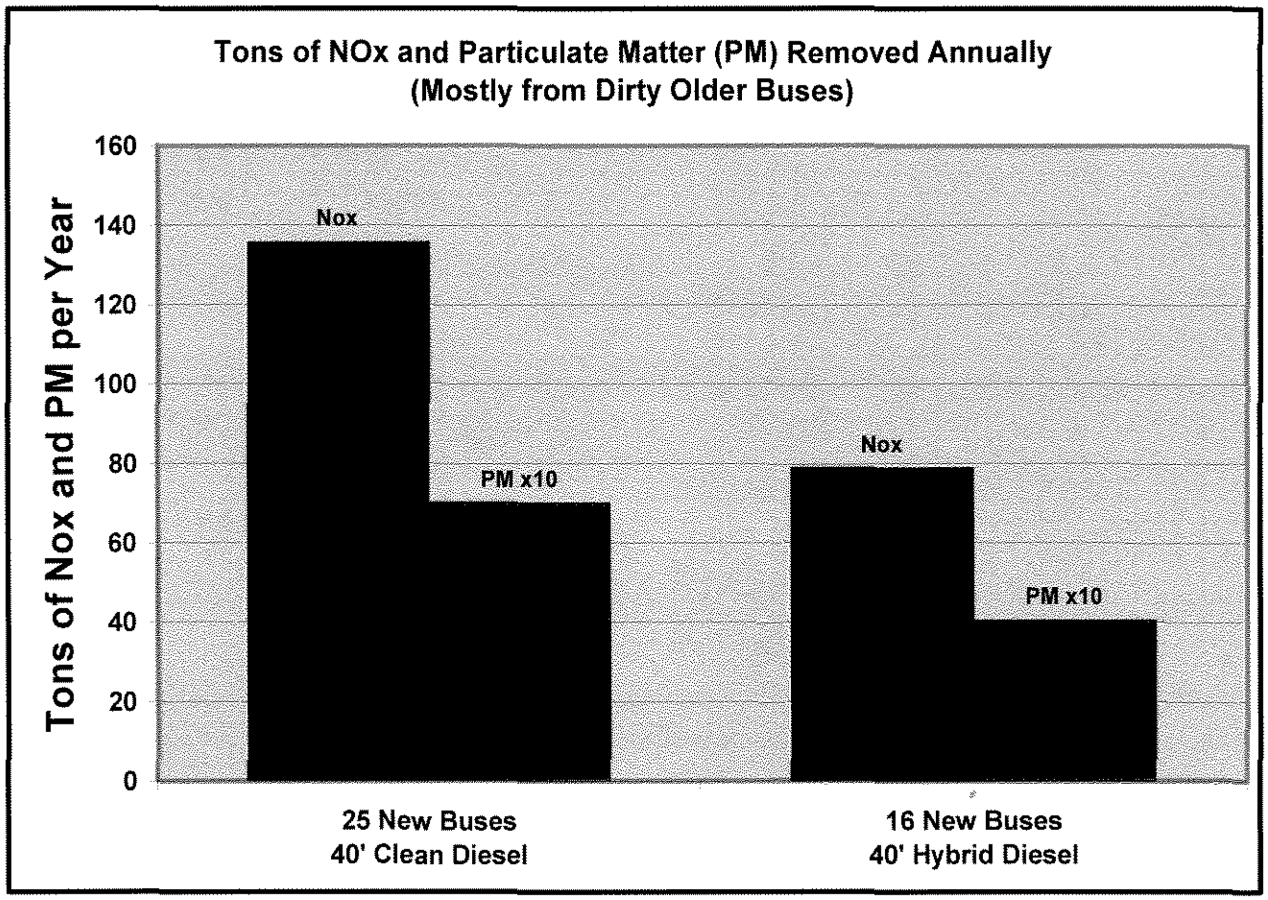
We have calculated the estimated emissions from our bus fleet based on the EPA standard in effect when older buses were purchased. The chart below displays the annual emissions of nitrous oxides (NO_x) per bus per year.



The following chart displays the annual emissions of particulate matter (pm) per year per bus. Older buses emit 25 times more pollutants than buses that meet the EPA 2007 standard. In 2010, even stricter standards will be in force.



A good environmental policy is to remove as many older, dirtier buses from the fleet as soon as possible. We did an analysis of the estimated total pollutants that could be removed from the atmosphere by new clean diesel buses compared to diesel-hybrid buses. We assumed that budgets were fixed, so more clean diesel buses could be procured for a given amount of CIP funding than diesel-hybrids, which are almost $200,000 more per bus. For purposes of this analysis, we credited the hybrids as being 50 percent cleaner than clean-diesel buses. This is twice as much credit as is allowed by the California Air Resources Board. However, the differences between clean diesel and diesel-hybrid are insignificant when compared to the amount of $NO_{(x)}$ or PM generated by older buses. We assumed that a budget of $9 million could procure 25 clean-diesel buses at $355,000 each or 16 diesel-hybrids at $545,000 each. We calculated the amount of pollutants that could be removed from the environment by each of these alternatives. The results are presented graphically below.



As can be seen, far more pollutants can be removed from the atmosphere by adopting a strategy to get rid of the oldest, most polluting buses faster. This analysis estimates the net amount removed (amount removed by older buses plus amount injected by newer buses).

Other Benefits of Hybrid Buses

Hybrid buses have other benefits besides fuel savings and emissions reduction. Hybrids are slightly quieter than conventional diesels at acceleration because the primary propulsion is the electric motors. Drivers generally prefer hybrids because they accelerate faster from a stop. Also, the ride quality of hybrid buses is superior to conventional diesels because the transmission uses an infinitely variable gearing which reduces the jerkiness of the ride.

<u>Summary</u>

Today's hybrids have not performed at the levels hoped for (and promised by the manufacturers). While most manufacturers tout fuel savings as high as 60 percent, in-service tests have produced results that are, at best, about half of that level. In fact, most hybrid fuel savings are in the range of about 20 percent. Hybrid-buses may have less maintenance costs in some braking and propulsion systems but the high cost of batteries likely off-set these savings. Today's hybrid buses are not cost effective unless fuel increases about 500 percent of the rate forecast by the Department of Energy.

Hybrid buses are about 50 percent more costly to purchase than clean diesel buses. While hybrid buses are cleaner than conventional buses—at least in the central city where stop and go conditions are heaviest—the differences between today's clean diesel buses and hybrids are insignificant when compared to older buses. Far more pollutants can be removed from the environment by adopting a policy to retire the maximum number of older buses by purchasing clean diesel buses without the surcharge for the hybrid propulsion system.

The City needs to reestablish an aggressive bus purchasing program to drive down the average age of the transit fleet to industry norms. Currently, Honolulu has the oldest bus fleet in the nation. Failure to address this aging fleet will eventually create maintenance and operational problems that will take years to overcome. We recommend that the City consider conventional diesels for the next few years so as to obtain the most buses with the available capital budget.

Given the backlog of buses beyond their effective life, an aggressive rehabbing program will be necessary for the next few years. But rehabbing will not diminish the need to purchase new buses. Rehabs can effectively extend the useful life of a bus from about 12-13 years to 16-17 years but buses eventually wear out. Given the demographics of the current fleet, purchase of buses is unavoidable.